# ENVIRONMENTAL TOBACCO SMOKE, INDOOR AIR QUALITY AND THE NEED FOR ADEQUATE VENTILATION

[Shorter version of CAS version ~~to~~, made later]

March 1992

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# ENVIRONMENTAL TOBACCO SMOKE, INDOOR AIR QUALITY AND THE NEED FOR ADEQUATE VENTILATION

During the past decade, public concern about indoor air quality and "sick building syndrome" has increased substantially. The concern has been stimulated by a variety of factors, ranging from reports of illness apparently caused by air quality problems in individual buildings to the actions of single-issue pressure groups -- particularly antismoking organizations seeking to have smoking restricted or banned in public places as well as in office workplaces. This paper addresses important questions raised by such pressure-group efforts -- specifically, whether smoking has a significant impact on indoor air quality and whether smoking restrictions or bans are an appropriate response to the concerns that have been expressed about smoking.

## I. Environmental Tobacco Smoke and Indoor Air Quality

A variety of studies from around the world, conducted in many different settings, have confirmed that tobacco smoke in the air -- often referred to as environmental tobacco smoke ("ETS") -- is at most a minor contributor to indoor air quality problems. In fact, smoking seldom contributes more than 25 to 30 percent of the particles found in the indoor air. Typically, the contribution is much less.[1/] A number of scientists have pointed out that, at such



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1/ Jenkins, R. and Guerin, M. (1992). The Chemistry of Environmental Tobacco Smoke: Composition and Measurement, Oak Ridge National Laboratories, Lewis Publishers, Inc.

levels, a nonsmoker would have to spend between 50 and 500 hours in an office, restaurant or other public facility to be exposed to a quantity of nicotine equivalent to that delivered by the smoking of a single cigarette.[2/] Still other studies have confirmed that, with few exceptions, smoking seldom adds constituents to the indoor air that are not already there from many other sources.[3/]

According to the National Institute for Occupational Safety and Health ("NIOSH") in the United States, only two percent of the buildings inspected in response to occupant complaints about poor indoor air quality proved to involve excessive levels of tobacco smoke.[4/] Almost half of the complaints were traced to inadequate ventilation. In many

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[2/] Oldaker, G. III (1990). Results from surveys of environmental tobacco smoke in offices and restaurants, Indoor Air Quality, Kasuga, M. (ed.), Springer Verlag, Berlin, at 99-104; Proctor, C., et al. (1989). Measurement of environmental tobacco smoke in an air-conditioned office building, Environ. Tech. Lett., 10: 333-338; Baker, R., et al. (1988). The build-up and decay of ETS constituents as a function of room conditions, Indoor Air and Ambient Air Quality; Jenkins, R. and Guerin, M. (1984). Analytical chemical methods for the detection of environmental tobacco smoke constituents, Env. J. Resp. Dis. Suppl., 133: 33-46; Bayer, C. and Black, M. (1987). Thermal desorption/gas chromatographic/mass spectrometic analysis of volatile organic compounds in the offices of smokers and non-smokers, Biomed. and Environ. Mass Spec., 14(8): 363-367.

[3/] Oldaker, id.; Sterling, T., et al. (1987). Environmental tobacco smoke and indoor air quality in modern office work environments, J. Occup. Med., 29: 57-62.

[4/] Melius, J., Wallingford, K., Keenlyside, R. and Carpenter, J. (1985). Indoor Air Quality -- The NIOSH Experience, presented at the American Society of Heating, Refrigeration & Air Conditioning Engineers, Atlanta, GA.

other cases, the air quality complaints were found to stem from chemicals produced by duplicating machines, carbon monoxide from basement parking garages and bacteria and fungi found growing in ventilation and heating systems.[5/]

The findings of private firms are generally consistent with those reported by NIOSH. For example, Healthy Buildings International ("HBI"), a leading international air quality and ventilation firm, has identified problems with tobacco smoke in only three percent of the buildings studied. HBI has found the three principal causes of the "sick building syndrome" to be inadequate ventilation (56 percent), inadequate filtration (59 percent) and contaminated ventilation systems (47 percent). These findings have led HBI to recommend a building-systems approach to improving indoor air quality in the vast majority of cases.[6/]

## II. The Role of Ventilation in Improving Indoor Air Quality

The quality of the air indoors can be affected adversely by a wide range of substances and activities, some originating or occurring indoors and others traceable to the outside air. It also is clear that symptoms of the "sick building syndrome," such as sore eyes, a dry throat, nose

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[5/] Ibid.

[6/] Robertson, G. (1990). Indoor pollution: Sources, effects and mitigation strategies, Environmental Tobacco Smoke, Proceedings of the International Symposium at McGill University, Ecobichon, D.J. and Wu, J.M. (eds.), Lexington Books, Lexington, MA, at 333-355.

irritation, fatigue, coughing, itching skin, nausea, headaches and respiratory problems, have become increasingly common among office workers in many countries. Because ETS is the most visible component of the indoor air, many people attribute their discomfort or health problems to other people's smoking. The coincidence of smoking and an outbreak of symptoms is simply assumed to be causally related. The findings of groups such as NIOSH and HBI indicate how wrong such first impressions tend to be.

In fact, when ETS accumulates within a building there can be no surer sign of the inadequacy of the building's ventilation system. It also means, of course, that other less visible pollutants are accumulating as well. Symptoms often attributed to ETS may be the result of exposure to contaminants such as formaldehyde from furniture and wallboards, carbon monoxide and nitrogen dioxide from heating systems or motor vehicles, ozone from office copiers, fungal and bacterial spores, cotton fibers and fiberglass fragments. These pollutants, allowed to accumulate because of inadequate or inadequately maintained ventilation systems, are far and away the predominant causes of the "sick building syndrome."[7/]

The term "sick building syndrome" is relatively new. The underlying problems are, to a large extent, a function of two developments: the energy crises of the 1970s and the



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7/ Ibid.

responsive spread of centrally air conditioned buildings with sealed windows. Energy conservation efforts have led many building owners and operators to reduce the amount of fresh air entering their buildings. Stale, dirty air often is simply recycled continuously.

In many buildings, air quality is further compromised by inadequate filtration. Poor filtration essentially ensures that any contaminants in the outside air -- whether from motor vehicles, factories or other sources -- will find their way indoors in largely undiluted form. In addition, poor filtration can lead to an accumulation over time of substantial quantities of dirt and other substances inside a building's air supply ducts. Combined with moisture, such accumulations can act as a breeding ground for bacteria and fungi, including the bacteria that causes Legionnaire's Disease. In addition, government and private investigators have discovered dead insects, birds, rodents, snakes and rotting food in air supply ducts. Discomfort as well as health problems on the part of building occupants are hardly surprising in such circumstances.

Building owners and managers sometimes respond to occupant air quality complaints by imposing total smoking bans in their buildings. Since ETS is a factor in only a small percentage of cases, however, smoking bans almost always fail to solve the problem. For example, one researcher has reported on the case of a new office building in the

Washington, D.C. area that became "sick" shortly after the employees moved in. In response to rising employee complaints and increased absenteeism, management called in a health inspector. Observing smoke-filled offices, he recommended a smoking ban, which failed to resolve the problem. A more comprehensive investigation revealed major ventilating system problems, including sealed outdoor air intakes, cheap, inadequate filters, and microbial contamination in the air handling units. Improved ventilation and maintenance resolved the problem, and no smoking restrictions were found to be needed.[8/]

Perhaps the most celebrated example of a "sick" building is the United States Environmental Protection Agency's own headquarters building in Washington, D.C. According to press accounts, many EPA employees became so ill when occupying the building that EPA was forced to move their offices to a nearby apartment building. An investigation ultimately revealed that the problem was caused primarily by chemicals emitted from newly installed carpeting, not by ETS.[9/]

These anecdotal reports are confirmed by the scientific data that have become available in recent years.

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[8/] Turner, S. (1991). Sick buildings: Causes and effects, presented at the Symposium on Indoor Air Quality and Health, Universita Degli Studi di Perugia, Perugia, Italia, 210-211.

[9/] Weiskopf, M. "For EPA, War on Pollution Strikes Home," The Washington Post, Dec. 12, 1989 at A23.

One recent study of 3,155 office workers in 18 air conditioned offices, for example, concluded that smoking policies had no effect on sick building syndrome symptoms.[10/] Banning or severely restricting smoking thus will not resolve indoor air quality problems. Reliance on smoking restrictions only detracts from more productive efforts to address indoor air quality problems comprehensively.

III. ANSI/ASHRAE Ventilation Standard 62-89

Growing awareness of the importance of proper ventilation and the futility of smoking bans has culminated in the publication of a new building ventilation standard by the American Society of Heating, Refrigeration and Air Conditioning Engineers ("ASHRAE"). ASHRAE Standard 62-89, "Ventilation for Acceptable Indoor Air Quality," specifies the rate at which fresh or outside air must be delivered to occupied spaces, including spaces in which moderate smoking is occurring.[11/] The standard recommends a ventilation rate of

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[10/] Hedge, A., Erickson, W.A. and Rubin, G. (1991). The effects of smoking policy on indoor air quality and sick building syndrome in 18 air-conditioned offices, presented at IAQ '91 Healthy Buildings, Washington, D.C. See also Liao, S., Bacon-Shone, J. and Kim, Y.S. (1991). Factors influencing indoor air quality in Hong Kong: Measurements in offices and shops, Environ. Tech., 12: 737-745.

[11/] American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE Standard 62-1980, Ventilation for Acceptable Indoor Air Quality, at 9 (1989). The standard recommends a rate of 60 cfm per person for dedicated smoking lounges. Other indoor environments with specialized uses, such as restrooms, drycleaning facilities and beauty parlors, also have recommended ventilation rates tailored to specific conditions.

20 cubic feet of fresh air per minute ("cfm") per person for most commercial facilities, with 15 cfm as the minimum. The standard also describes acceptable concentrations of various indoor contaminants, which is an alternative to the ventilation-based approach recommended in the standard.[12/]

In adopting Standard 62-89, ASHRAE rejected the dual ventilation approach of an earlier proposed standard known as ASHRAE Standard 62-81. The 1981 proposed standard had recommended a minimum of 5 cfm of outside air per person be used in building design for areas where smoking was not permitted. In smoking-permitted areas, the recommended ventilation rate was 20 cfm/person.

This dual ventilation approach proved quickly to be both unworkable and misguided. It was, as a consequence, ultimately rejected by the pertinent reviewing authority -- the American National Standards Institute ("ANSI"). The major problem with the 5 cfm/person ventilation rate recommended in Standard 62-81 was that it permitted the indoor concentration of carbon dioxide ($CO_2$) from human breathing to reach 2,500 parts per million (ppm). It quickly became apparent that 2,500 ppm $CO_2$ was much too high to ensure occupant comfort. In addition, the 5 cfm/person rate permitted other pollutants

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[12/] As discussed above, air quality can be affected adversely by poor filtration as well as inadequate ventilation. ASHRAE Standard 62-89 does not contain an independent filtration requirement, recommending instead that air filters and dust collectors be selected for the expected particle size and loading. Standard 62-89 cross-references ASHRAE Standard 52-76 for filter testing.

to accumulate to problematic levels, thus prompting rather than reducing occupant complaints.

The 20 cfm/person ventilation rate recommended in ASHRAE Standard 62-89 is designed to keep indoor $CO_2$ levels below 1,000 ppm, thus ensuring greater occupant comfort. This level of $CO_2$ is consistent with actions that have been taken by other countries, such as Japan, which also attempt to limit indoor $CO_2$ levels to 1000 ppm.

In January 1991, ANSI adopted ASHRAE Standard 62-89 as the official American National Standard for building ventilation. The International Standards Organization currently is considering the same standard for adoption internationally. Ventilating to the ASHRAE standard is the single most effective step an employer can take to safeguard the comfort and health of employees.

## IV. Benefits of Adequate Ventilation

Many employers, building owners and building managers are reluctant to invest in improved indoor air quality because they fear increased energy and other costs. In fact, the costs associated with improved ventilation are remarkably modest. In most cases, moreover, increased energy costs are more than offset by reduced absenteeism and improved productivity.[13/]

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[13/] See generally Holcomb, L. and Pedelty, J. (1991). Comparison of employee upper respiratory absenteeism costs with costs associated with improved ventilation, paper submitted to ASHRAE Journal; Steel, T. and Brown, M. (1990).
(continued...)

Respiratory problems alone have been estimated to be responsible for about 150 million lost work days annually in the United States.[14/] Although poor indoor air quality does not account for all respiratory problems, the evidence suggests that it plays a significant role. For example, a four-year study of American army recruits conducted by the Walter Reed Army Institute revealed that trainees housed in modern, energy efficient barracks were about 50 percent more likely to contract a respiratory infection than were trainees in older, less tightly sealed buildings.[15/]

Such studies confirm the cost effectiveness of improving ventilation. Consider the case of a typical 100,000 square foot office building in Washington, D.C., housing 667 employees. If outside air intake is increased from 5 cfm to 20 cfm per person, the maximum additional cost has been estimated at approximately $18,500 per annum. This is the

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[13/](...continued)
Energy and cost implications of ASHRAE Standard 62-89, Bonneville Power Authority Report; Flatheim, G. (1990). IAQ upgrades do not ruin budgets. Proc. of the Fifth International Conf. on Indoor Air Quality and Climate (Indoor Air '90), Toronto, Canada, 4: 59-64; Eto, J.H., and Meyer, C. (1988). The HVAC costs of increased fresh air ventilation rates in office buildings. ASHRAE Transactions, Vol. 94, Pt. 2, Atlanta, GA.

[14/] Dixon, R.E. (1985). Economic costs of respiratory tract infections in the United States, Am. J. Med., 78: 45-51 (Supp. 6B); Garibaldi, R.A. (1985). Epidemiology of community acquired respiratory tract infections in adults, Am. J. Med., 78: 32-37 (Supp. 6B).

[15/] Brundage, J.F., et al. (1988). Building associated risk of febrile acute respiratory diseases in army trainees, J. Am. Med. Assn., 259: 2108-2112.

equivalent of $28 per employee per year. On the other hand, if one conservatively assumes an average annual employee salary of $30,000, the minimum cost of a one percent absenteeism rate would be $200,000, or $300 per employee per year. If better ventilation reduced absenteeism by as little as one-half of one percent, the employer would recover his costs several times over.[16/] As this hypothetical illustrates, improving indoor air quality offers quantifiable benefits to cost-conscious managers. Although the form of currency may differ from one country to another, there is no reason to believe that a different conclusion would be reached in other countries.

V. Conclusion

ETS is not a significant cause of poor indoor air quality or the sick building syndrome. Most such symptoms stem from poorly maintained or inadequate ventilation and filtration systems. In the vast majority of instances, a ventilation rate of 20 cfm of fresh air per person is sufficient to deal with smoking as well as the many other indoor air components that can accumulate in the absence of adequate ventilation. Cost-conscious managers can be quite confident that the costs of improved ventilation will be more than offset by the benefits of reduced absenteeism and improved productivity.



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16/ Turner, supra note 8, at 209.